means an easy one, the distance being measured as 4″·19 (1890 April 22). Since that date, especially during the last two years, several observers have attempted to catch a glimpse of this body with varying results. Dr. See, in a communication on this subject (*Astr. Journal*, No. 418), points out that although several objects have been measured which were thought at the time to be the companion in question, there seems to be evidence to show that in some cases these were spurious. There is, however, no doubt that the companion can now be seen, and several measures show that it is following with great accuracy the orbit which Dr. See computed for it in his work on "Researches on the Evolution of the Stellar Systems" (vol. i. p. 84). The satisfactory agreement of the observed and computed positions shows that this orbit is of a high degree of accuracy, and will be serviceable for many years to come. The following ephemeris, taken from Dr. See's paper, gives the position angles and distances for the next three years:—

	Pos. angle.	Distance.
	°	″
1897·70	174·5	4·59
1898·20	169·0	4·72
1899·20	158·9	4·97
1900·20	149·5	5·25

A Liberal Gift to Astronomy.—It was briefly announced in last week's Nature that Miss Alice Bache Gould, daughter of the late Dr. Gould, had entrusted to the U.S. National Academy of Sciences a fund of 20,000 dollars; we are now able to state the precise conditions under which the gift was made. The money given by Miss Gould is to be known as the Benjamin Apthorp Gould Fund, and the net income of the fund is to be expended under the direction of Prof. Lewis Boss of Albany, Dr. Seth C. Chandler of Cambridge, and Prof. Asaph Hall of Washington, who are constituted by Miss Gould a board of directors for that purpose. The income is to be devoted to the prosecution of researches in astronomy by assisting observers and investigators in such manner and sums as may be agreed upon by all three of the directors.

In a letter to the directors, Miss Gould writes:—"My object in creating the fund is two-fold; on the one hand to advance the cause of astronomy, and on the other to honour my father's memory and to ensure that his power to accomplish scientific work shall not end with his own life. . . . Throughout my father's life his patriotic feeling and scientific ambition were closely associated, and I wish therefore that a fund bearing his name should be used primarily for the benefit of investigators in his own country or of his own nationality. I recognise, however, that sometimes the best possible service to American science is in the maintenance of close communion between the scientific man of Europe and of America, and that therefore, even while acting in the spirit of the above restriction, it may occasionally be best to apply this money to the aid of a foreign investigator working abroad."

One idea in the creation of the fund is that it may relieve the directors of the Bache fund of the Academy of some of their astronomical expenses, so that they may be able to devote more of their money to other departments. Miss Gould expresses a strong wish that astronomy of precision shall be distinctly preferred to work in astrophysics, first, because of Dr. Gould's personal preference, and, second, because of the existence of endowments for astrophysics. The fund is distinctly intended for the advancement and not for the diffusion of scientific knowledge; actual expenses of investigation are to be considered rather than the personal support of investigators, and the directors are advised not to cover with their grants the field provided for by existing endowments.

CORAL BORING AT FUNAFUTI.[1]

THE boring at Funafuti, according to the latest advices, had reached a depth of 643 feet. Prof. David's report is transcribed from notes made during the progress of the work, and gives his first impressions of the materials brought up, down to a depth of 557 feet, which had been reached when he quitted the island to return to his duties at Sydney, leaving the work in charge of his assistant. The latest advices informed him that the boring was arrested at 643 feet, but as it was hoped this was only for a time, we are daily expecting to hear yet more gratifying news. His last letters, received during the present week, give a few particulars of the materials pierced between 557 and 643 feet. The work, states Prof. David, often presented most serious difficulties, which would probably have frustrated their efforts, but for the experience gained on the former occasion.

The bore-hole is situated about half a mile north-east of the Mission Church, and its height above sea level is about 1 foot above high water mark at spring tides. The diameter is 5 inches down to 68 feet; it is lined with 5-inch tubing down to 118 feet, and 4-inch from surface to 520 feet, so that on September 6 a 4-inch core was being obtained.

The following is a general description of the materials pierced:—For about a yard at the top there was a hard coral breccia. This was followed down to a depth of 40 feet by "coral reef rock," into the composition of which *Heliopora cerulea*, with spines of echinids and nullipores entered largely, the last predominating over the coral at from 15 to 20 feet. From 40 to 200 feet came more or less sandy material, but with a variable quantity of corals. These were scattered through the sand (calcareous and of organic origin; foraminifera, at about 40 feet, making from one-half to two-thirds of the whole) sometimes as fragments (forming occasionally a kind of rubble), but sometimes in the position of growth. Between 120 and 130 feet, and from about 190 to 200 feet, the material is described as fairly compact coral rock, so that very probably reefs *in situ*, though of no great thickness, were pierced at these depths. The sand appears to be largely derived from coral, but foraminifera occur, sometimes in abundance; so too do nullipores, and here and there spines of echinids. Towards 150 feet signs of change begin to appear in the corals, and these become more conspicuous as the boring approaches its greatest depth. In such case, if I understand rightly, some of the branching corals crumble away and are represented only by casts, while others remain, the surrounding matrix becoming solid, cemented apparently by calcite. Below 202 feet a decided change takes place in the character of the deposit. All above this seems to be largely composed of material derived from corals, with occasional rather brief interludes of true reef; and this mass, measuring, as said above, rather over 200 feet in thickness, may be termed the first or uppermost formation. Below this, down to about 373 feet, sandy material distinctly dominates, which sometimes is almost a calcareous mud. Still even there coral fragments and rubble occasionally appear, and now and then a few isolated corals. Other organisms may be detected, including nullipores, foraminifera, and mollusca; but until this material has been examined microscopically, it would be premature to attempt any precise statement. This mass, in thickness about 170 feet, may be termed the second or middle formation. It is not reef, though obviously produced in the vicinity of a reef. Below 370 feet is the third or lowest zone; in this beds composed of broken coral become frequent, which are intercalated with masses of dead coral, though sandy bands also occur. The character of the material suggests that it has been formed in the immediate vicinity of a reef, which has occasionally grown out laterally, though only for a time, and has built up a layer of true reef, from 2 to 3 feet in thickness, upon a mass of detrital coral. In one place the rock is specially noted as "hard," and hereabouts even the shells of gastropods have perished, only their casts remaining. From 526 to 555 feet the bore passed through fairly compact and (in places) very dense and hard "coral limestone" and "cavernous coral rock," in which dendroid forms were numerous. As regards the part between 557 feet and 643 feet only brief information is to hand, but Prof. David states that it is reported to be chiefly coral limestone, hard and dense, with occasional soft bands of coral sand or coral rubble. Thus the third, or lowest zone, about 270 feet in thickness, corresponds apparently with the first, but it seems to contain larger and more numerous masses of true reef.

Prof. David has also forwarded with his latest letters a section of the boring and of the exterior form of the island, down to about 730 fathoms: the one drawn from his notebook, the other from Captain Field's record of soundings. From this I gather the following particulars:—The bore-hole is, roughly speaking, rather over 100 yards from the margin of the ocean, and about 165 yards from that of the lagoon; it is about 240 yards from the spot where a sounding of 10 fathoms was obtained,

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[1] "Summary of Prof. Edgeworth David's Preliminary Report on the Results of the Boring in the Atoll of Funafuti." Communicated by Prof. T. G. Bonney, F.R.S., Vice-Chairman of the Coral Reef Boring Committee. Read at the Royal Society, November 25.

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nearly 400 yards from a 36-fathom sounding, and rather more than a quarter of a mile from one of 130 fathoms. After this the submarine slope, for a considerable depth, is not quite so steep. He also states that, at Funafuti, the vigorous growing portion of the reef appeared to be limited to within about 40 feet of the surface.

It would be premature, as Prof. David remarks, to express an opinion as to the theoretical bearing of these results until the core has been thoroughly studied. But two things seem clear, (1) that true reef has been pierced at depths down to more than 600 feet, and (2) that throughout the whole of the time represented by the mass which has been tested, coral must have grown in great abundance in some part or other of the locality now represented by Funafuti; for the atoll, it must be remembered, is surrounded by water about 2000 fathoms deep, which would completely isolate it from any other coraliferous locality.

THE VITALITY OF REFRIGERATED SEEDS.[1]

A CONSIDERABLE difference of opinion still exists amongst biologists as to the condition of the protoplasts of resting seeds, spores, &c., in which all ordinary signs of life may be unrecognisable for a considerable period.

According to one view, the essential elements of the cell, during the period of inertness, are still undergoing feeble but imperceptible alteration, accompanied by gaseous exchange with the surrounding atmosphere; and, even when ordinary respiration is in abeyance, it is assumed there are small internal changes going on, due to the interaction of certain constituents of the protoplasm, reactions which may be independent of the outside gaseous medium, and which are often referred to under the somewhat vague term of "intramolecular respiration."

On the other hand, it is sometimes maintained that all metabolism is completely arrested in protoplasm when in the dormant state, and that it then loses, for the time being, all power of internal adjustment to external conditions.

According to one view, therefore, the machinery of the dormant protoplasts is merely "slowed down" to an indefinite extent, whilst according to the other it is completely brought to rest for a time, to be once more set going when external conditions are favourable.

It appears to us that the advocates of the "slowing-down" hypothesis have scarcely given sufficient attention to the experimental evidence available, and that they have been somewhat biassed by a supposed analogy between the dormant state of seeds and the hibernating state in animals, and have also, perhaps, been unconsciously influenced by Mr. Herbert Spencer's well-known definition of life, which implies a constant internal adjustment in the living protoplasm.

The experiments of the late G. J. Romanes, which were described in a short paper laid before the Society in 1893 (*Roy. Soc. Proc.*, vol. lvii. p. 335), are full of interest in their bearing on this question. Seeds of various plants were submitted in glass tubes to high vacua of 1/1000000 of an atmosphere for a period of fifteen months. In some cases, after the seeds had been *in vacuo* for three months, they were transferred to other tubes charged respectively with oxygen, hydrogen, nitrogen, carbon monoxide, carbon dioxide, hydrogen sulphide, aqueous vapour, and the vapour of ether and chloroform. The results proved that neither a high vacuum, nor subsequent exposure for twelve months to any of the above gases or vapours, exercised much, if any, effect on the subsequent germinative power of the seeds employed.

These experiments of Romanes are certainly of the highest importance, since the seeds were submitted for a long period to conditions which must certainly have excluded anything like respiration by ordinary gaseous exchange, but the conditions did not preclude with the same certainty the possibility of chemical interactions of some kind or other within the protoplasm, those ill-understood changes, in fact, which have been referred to "intermolecular respiration." It is true that in some of the experiments, notably those in which the vapours of chloroform and ether were employed, the probability of any such internal reactions is rendered somewhat remote; but still, in most cases, the experiments admit of the possibility of feeble metabolic activity continuing in the cytoplasm.

It occurred to us, some months ago, that more evidence would probably be forthcoming on these points if we could submit seeds to a temperature below that at which ordinary chemical reactions take place, thus eliminating any possibility of interactions between the constituents of the protoplasm.

Owing to the kindness of Prof. Dewar, who has been good enough to place the resources of his laboratory at our disposal, and to undertake this part of the work for us, we have been able to ascertain how far the subsequent germinative power of a considerable variety of seeds is affected by prolonged exposure to the very low temperatures produced by the slow evaporation of *liquid air*.

The seeds, enclosed in thin glass tubes, were slowly cooled, and immersed in a vacuum-jacketed flask containing about two litres of the liquid air, which was kept replenished so as to submit the seeds for 110 consecutive hours to a temperature of from – 183° C. to – 192° C. About ten litres of liquid air were required for the experiment.

The seeds had been previously air-dried only, so contained from about 10 to 12 per cent. of natural moisture. After the above treatment they were slowly and carefully thawed, a process which occupied about fifty hours, and their germinative power was then compared with control experiments made on other portions of the seed which had not been treated in any way.

The seeds experimented on were as follows:—

Hordeum distichon.
Avena sativa.
Cucurbita Pepo.
Cyclanthera explodens.
Lotus Tetragonolobus.
Pisum elatius.
Trigonella fœnum-græcum.
Impatiens balsamina.
Helianthus annuus.
Heracleum villosum.
Convolvulus tricolor.
Funkia sieboldiana.

These include representatives of the following natural orders:—Gramineæ, Cucurbitaceæ, Leguminoseæ, Geraniaceæ, Compositæ, Umbelliferæ, Convolvulaceæ, and Liliaceæ.

Some of the seeds are endospermous, others non-endospermous, and the reserve material consists in some cases of starch, and in others of oil or of mucilage.

Their germinative power, after being submitted to the low temperature, showed no appreciable difference from that of the controls, and the resulting plants, which were in most cases grown to full maturity, were equally healthy in the two cases.

In 1892 Prof. Dewar and Prof. McKendrick found that a temperature of – 182° C continued for one hour is insufficient to sterilise putrescent substances such as blood, milk, flesh, &c., and that seeds would germinate after the action of a similar temperature for the same period of time (*Roy. Inst. Proc.*, 1892, vol. xiii. p. 699).

When we commenced our experiments we were unaware that any other observations of a similar nature had been made, but whilst they were in progress our attention was drawn to an important memoir by C. de Candolle,[1] in which the latent life of seeds is discussed in the light of a number of low temperature experiments made principally by himself and R. Pictet, and described at intervals in the Geneva "Archives."[2] In the earlier experiments of C. de Candolle and Pictet, made in 1879, temperatures of – 39° C. to – 80° C. were employed, and these only from two to six hours; whilst Wartmann in 1881 exposed seeds for two hours to – 110° C. without effect. In 1884 Pictet found that an exposure of various kinds of Bacteriaceæ for three days to – 70° C., and afterwards for a further period of thirty-six hours to – 120°, did not destroy their vitality, and in the same year Pictet and C. de Candolle exposed seeds to – 100° C. for four days with the same result. Pictet, in 1893, further extended his observations to various microbes, and also to a large number of seeds, and claims to have cooled them down without effect to nearly – 200° C., but he gives no details of the experiments, nor any indication of the length of time during which the cooling lasted. His conclusions, however, are that, since all chemical action is annihilated at – 100° C., life must be a manifestation of natural laws of the same type as gravitation and weight.

In his memoir of 1895 (*loc. cit.*) C. de Candolle discusses very fully whether we must regard the life of the resting seed as com-

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[1] "Note on the Influence of very Low Temperatures on the Germinative Power of Seeds." By Horace T. Brown, F.R.S., and F. Escombe. (Read before the Royal Society, November 18.)

[1] *Archives des Sci. Phys. et Nat.*, Geneva, 1895, vol. xxxiii. p. 497.

[2] E. Wartmann, 1860, *Archives des Sci. Phys. et Nat.*, 1860, p. 277; C. de Candolle and Pictet, 1879, *ibid.*, vol. ii. p. 354; *ibid.*, vol. ii. p. 629; E. Wartmann, 1881, *ibid.*, vol. v. p. 340; R. Pictet. 1884, *ibid.*, vol. xi. p. 320; R. Pictet and C. de Candolle, *ibid.*, p. 325; R. Pictet, 1893, *ibid.*, vol. xxx. p. 293; C. de Candolle, 1895, *ibid.*, vol. xxxiii. p. 497.

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